

# Extrusion Technology and its Application in Seafood System: A Review

K.G. Baraiya<sup>1</sup>, S.R. Lende<sup>2</sup>, R.A. Khileri<sup>3</sup>, V. Shrivastava<sup>4</sup> and Vikas<sup>5</sup>

<sup>1,2,3</sup>College of Fisheries, JAU, Veraval, Gujarat

<sup>4,5</sup>Central Institute of Fisheries Education, Mumbai

**Abstract**—With increase demand for fish and fishery products World over, supply of acceptable quality fish and fishery products for increasing population is being accorded top priority by planners. About 20-25% of total fish catch is lost either due to spoilage because of its inherent characteristics or also due to lack of required infrastructure for its preservation and utilization. In order to utilize by-catches, which are normally of low economic value but not in nutritional value, attempts are being made for the development of product using novel processing techniques so as to reach the consumer at affordable prices. Extrusion technology is nowadays a promising technology for production of breakfast foods and ready to eat foods. Such products based on cereal and pulse flour are generally deficient in important nutrient like protein, essential amino acid and fatty acid etc. Incorporation of fish to cereal based extruded products will proportionally enrich the nutritive value of such products.. The development of fish based extruded food items will enhance the utilization of low value fish with high nutritional constituents. The advantage of developing fish based engineered product will help in supplying balanced diets to undernourished people in developing countries as well as opening new avenues for local entrepreneurship.

## 1. INTRODUCTION

Extrusion is a process which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming. Extrusion cooking, which is a continuous, high-temperature, short-time process, has become popular economical process to formulate new cereal foods. Extruders are classified according to the method of operation (cold extruders or extruder-cookers) and the method of construction (single or twin-screw extruders).

The principles of operation are similar in all types: raw materials are fed into the extruder barrel and the screw then convey the food along it. Further down the barrel, smaller flights restrict the volume and increase the resistance to movement of the food. As a result, it fills the barrel and the spaces between the screw flights and becomes compressed. As it moves further along the barrel, the screw kneads the material into a semi-solid, plasticized mass. If the food is heated above 100°C the process is known as extrusion cooking (or hot extrusion). Here, frictional heat and any additional heating that is used cause the temperature to rise rapidly. The

food is then passed to the section of the barrel having the smallest flights, where pressure and shearing is further increased. Finally, it is forced through one or more restricted openings (dies) at the discharge end of the barrel as the food emerges under pressure from the die, it expands to the final shape and cools rapidly as moisture is flashed off as steam. A variety of shapes, including rods, spheres, doughnuts, tubes, strips, squirls or shells can be formed. Typical products include a wide variety of low density, expanded snack foods and ready-to-eat (RTE) puffed cereals.

Types of product	Example
Cereal-based products	Expanded snack foods RTE and puffed breakfast cereal Weaning foods Pre-gelatinized and modified starches, dextrins Crisp bread and croutons Pasta products Pre-cooked composite flour
Sugar-based products	Chewing gum Liquorice Toffee, caramel, peanut brittle Fruit gums
Protein -based products	Texturised vegetable protein(TVP) Semi-moist and expanded pet foods and animal feeds and protein supplement Sausages products, frankfurters, hot dogs Surimi Caseinates Processed cheese

**Adapted from Harper (1979), Harper (1987), Heldman and Hartel (1990) and Best (1994).**

## 2. BACKGROUND OF EXTRUSION TECHNOLOGY

### 2.1. Extrude

The verb “extrude” describes a process of shaping by forcing softened or plastized material through dies or holes by pressure. A food extruder is a device that facilitates the shaping and restructuring process for food ingredients.

## 2.2. Extrusion cooking

Extrusion cooking is a modern HTST (High Temperature Short Time) process is being increasingly used in food and technical industries. New products are being created and well-known ones are copied and made more advantageous by replacing conventional machines and equipment by extruder cookers, which are carrying out many of the physico-chemical processes. Extruder cookers are used as HTST pieces of equipment for the processing of vulnerable food materials. Their function is to rupture cell walls by heating and shearing, making the cell contents available for mixing and reaction with other components. The extruder function is to denature the raw material, in order to make them available for safe digestion. In combined product industries, like the pet food industry, the summation of starch and protein processing is executed in cooking extruder simultaneously and much emphasis is put on controlling reactions while mixing operations are executed in the extruder equipment.

The extruder still offers a small reaction volume, which can be very well controlling vapour pressure, the residence time and the viscosity of the confectionery mix in the extruder. It is the infinite flexibility of extruder design, which makes them attractive as versatile production equipment in the confectionery industry. Continuous high temperature short time extrusion cooking is not a new technology as such but an understanding of it, is of current interest. Over the last fifty years there has been an art of food extrusion and much work has been done on empirical basic studies dealing with the thermoforming of plastics. Only in recent times some of the basic thermo-mechanical transformations of food ingredients in the extruder have been understood.

## 2.3. Principle of extrusion cooking

From an engineering point of view, a cooking extruder is a combination of a pump and a heat exchanger. The raw material is fed in to the extruder through the hopper and forced forward, toward the die, by the rotation of the one or more screws. The barrel wall is generally heated by electric heaters or by oil jackets, although for simple starch

gelatinization adiabatic extruders are also used. The heat is provided purely by viscous dissipation.

## 2.4. Purpose of extrusion

1. **Sterilization:** The heat and pressure produced in the extruder can be utilized for bacterial, mold and yeast destruction.
2. **Expansion:** The continuous pressure cooking and sudden release of pressure allows the gelatinization of starch cells, oil rupture, and shaping and texturizing the product.
3. **Dehydration:** Within certain parameters, a 50% loss in moisture can be achieved through the extrusion process. This allows for dehydrating many products, which have too high a moisture level for storage.
4. **Stabilization:** The use of heat and pressure can be used to inactivate enzymes that would occur in rice bran and in various other ingredients causing rapid destruction of the nutritional properties.

## 3. OPERATING CHARACTERISTICS

The most important operating parameters in an extruder are:

- Temperature
- Pressure
- Diameter of the die apertures
- Shear rate.

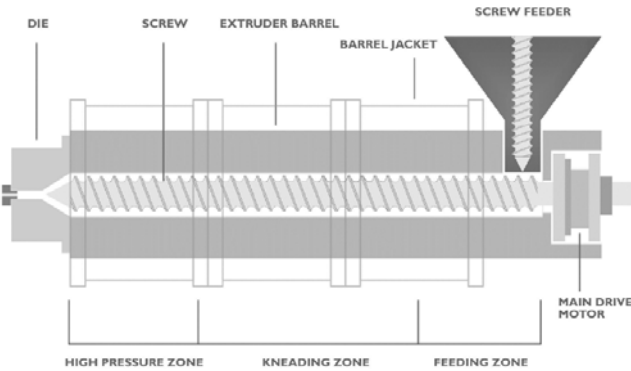
The shear rate is influenced by the internal design of the barrel, its length and the speed and geometry of the screw. Most research on model extruders has been done with single-screw machines because twin-screw extruders are substantially more complex. In operation, the single-screw extruder acts as a type of pump, dragging the food through the barrel and increasing the pressure and temperature before the food is forced through the die. For optimum pumping, the food should stick to the barrel and slip freely from the screw surface (Heldman and Hartel, 1997). However, if food slips on the barrel it does not move through the extruder and is simply mixed.

## 4. Type of Extruder Machine

Extruders are composed of five main parts:

- 1) The pre-conditioning system,
- 2) The feeding system,

- 3) The screw or worm,
- 4) The barrel,
- 5) The die and the cutting mechanism.



**Fig. 1: Schematic representation of an extruder including its main parts and zones.**

There are 3 major type of extruder used in the food industry:

1. Piston extruder
2. Roller type extruder
3. Screw extruder

**5. INFLUENCE OF PROCESS ON RAW MATERIAL PROPERTIES**

**5.1 Starch**

It is also important to consider ingredients properties during extrusion. Each individual starch source has its strong point. The fine main cereal grain starch options include rice, (long, medium or short grain) wheat (soft, hard) corn (white or yellow), barleand soats. The main objective of extrusion of starch are apart from shaping,to break down the starch granules and to gelatinize their contents. As a result of the moisture added during the process, the starch particle swell and owing to thermal influence, loss their rigidity,part of the amylose diffuses out.The high shear in the extruder rupture the particle so that all the amylose and amylopection becomes available to form an amorphous mass. Although some degradation of the large molecules can occur during extrusion, no monosaccharides are believe to be formed because of the short residence time at the high temperature.

**5.2 Protein**

The main function of extrusion in protein processing is to denature and to texturize. As a result of the high temperature and shear forces in the extruder, the intramolecular bonds in the protein molecule are broken and the protein denatures. Subsequently, these bonds can

recombine with their counter parts from other molecules thus forming an intermolecule cross-linked network in the form of strands.The shear forces in the extruder will align these strand to give the product the desire texture. For good alignment and structure, the flow conditions in the die are very important.

**5.3 Stability of end products**

Various enzymes and microorgnisms can spoil food product if they are not inactivated or killed during processing. Lipase and lipoxygenase may, for example easily cause off flavours. Mirosinase may release the toxin isothiocyanate, and nutrient destruction can occur through various residual enzymatic activities. Enzyme inactivation therefore contributes to the storage stability and safety of the product.The influence of extrusion condition on enzyme inactivation increase with increasing extrusion temperature shear and pressure.

**6. APPLICATION OF EXTRUSION PROCESS IN FOOD SYSTEM**

<ul style="list-style-type: none"> <li>• Confectionary product</li> <li>• Beverage product</li> <li>• Breakfast cereals</li> <li>• Snacks</li> <li>• Texturized plant product (Texture vegetable protein)</li> <li>• Blended products</li> <li>• Pasta products</li> <li>• Restructed muscle foods</li> <li>• Instant soup and gravy bases</li> <li>• Conventional bakery products</li> </ul>	<ul style="list-style-type: none"> <li>• Pet foods</li> <li>• Animal feed</li> <li>• Sugar decrystallization</li> <li>• Modified starches and starch degradation products</li> <li>• Protein modification</li> <li>• Conversion of cellulose</li> <li>• Meat analogs</li> <li>• Frozen products</li> <li>• Instant noodles</li> <li>• Non-traditional Application of extrusion</li> </ul>
---	---

**7. EXTRUSION APPLICATION ON SEA FOOD SYSTEM**

Food and Agricultural Organization (FAO 1995) estimated that by the year 2010 the world’s demand for fish as food for humans is 110 to 120 million tons. Ten per cent of the total catch consists of fish that are underutilized because of undesirable features like small size, dark meat, high fat content, strong flavour, high bone content, unacceptable textural properties, and/or the possible presence of toxic substances. Utilization of low-value fishes is of great importance in developing countries. Processing these fishes using high temperature or pressure, called extrusion cooking, will help modify the texture and other physical properties and make them suitable for human consumption. Co-extrusion of these fishes with cereals like rice and wheat yields nutritional products with good textural attributes and proximate composition of the extrudates (Bhattacharya *et al.* 1992).

In the recent time, extruded products are gaining wide popularity. Most of the extruded snacks are cereal and thus less protein content and are limited in some essential amino acids. The incorporation of protein rich fish mince or fish flour would increase the nutritional value of such products. Fish mince or fish flour would increase the nutrition value of such products. Fish mince or fish flour blended with cereal flour can be coextruded to obtain a nutritious snack without compromising the quality of final product. Fish which lacks good market in fresh condition, can be easily utilized for this purpose either by mincing or making fish flour. Fish are not only excellent source of high nutritional value protein but also excellent source of lipid that contain omega-3 fatty acid, especially Eicosapentaenoic acid (EPA) and Docasahexaenoic acid (DHA).

<b>8. Advantages of Extrusion Cooking</b>	<b>9. Limitation of Extrusion Cooking</b>
1. Versatility 2. High productivity 3. Low cost 4. Product shapes 5. High product quality 6. Enery efficient 7. Production of new food 8. No effluents	1. High capital cost 2. Non availability of spare parts 3. Repair and maintenance 4. Power failure 5. Increased packaging cost 6. Start-up time is high

## 8. CONCLUSION

In the last three decades, the development of extruders has advanced greatly. Extrusion technology is starting to exert itself in to all areas of food manufacturing. More and more food companies that used conventional methods for the production of these and other related products are slowly

replacing their old processing systems with extruders. Current research work carried out with cooking includes the extrusion of starch and fish meat mixtures to modify the starch characteristics and possibly forming a new protein rich food. Now day's fish based extruded products production in experimental base and not commercially. But market of fish based extruded product will been grow up in next generation year and is expected to do so over the next several years primary of health concern from consuming too much fish meat. In the future science and technology of the extrusion field, scientists and engineers should focus on the relationship between composition changes and product quality, evaluating and enhancing nutritional, sensory and functional properties of extruded foods.

## REFERENCES

- [1] Best, E. T.1994. Confectionery extrusion. *In: Frame, N. D. (ed.).The Technology of Extrusion Cooking. Blackie Academic and Professional, Glasgow. Pp.190–236. Prep. Foods. 11:60–63.*
- [2] Bhattacharya, S.; Das, H. and Bose, A. N.1992. Rheological behavior during extrusion of blends of minced fish and wheat flour. *Journal of Food Engineering. 15 (2): 123–137.*
- [3] FAO.1995. World agriculture Organization: towards 2010. *In: Alexandros N. (Ed.), An FAO study. pp. 488.*
- [4] Harper, J. M.1979. Food extrusion.*CRC Crit. Rev. Food Sci. Nur.*pp. 155–215.
- [5] Harper, J. M.1987. High-temperature short-time extrusion cooking. *In: Turner, A. (ed.) Food technology international Europe. Sterling Publications International, London.pp. 51–55.*
- [6] Heldman, D. R. and Hartel, R. W.1997. Principles of Food Processing. Chapman and Hall, New York. Pp.253–283.